# Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

**Submission Title:** [Medical Body Area Network Application]
**Date Submitted:** [March 7, 2008]
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**Re:** [ IEEE P802.15 TG6 (Body Area Networks) Call For Applications, Jan 2008, IEEE P802.15-08-0069-01-0006]

**Abstract:** [This presentation is a response to the 802.15.6 Body Area Networks call for applications]

**Purpose:** [To contribute application specific requirements and technical needs for consideration and discussion by the group. To inform the group on a proposal submitted to the FCC for MBAN service.]

# Medical Body Area Network Application

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# Agenda

- Medical Body Sensor Networks
  - Description and Benefits
  - Clinical Environment Requirements
- Medical Body Area Network Service
  - Rules Proposed to FCC
  - Coexistence

# Challenges to Healthcare

- An aging population
- Sicker, higher acuity patients
- Staff overload and fatigue
- Quality and safety imperatives
- EMR directives
- Tightening margins

# Quantified Challenges to Healthcare

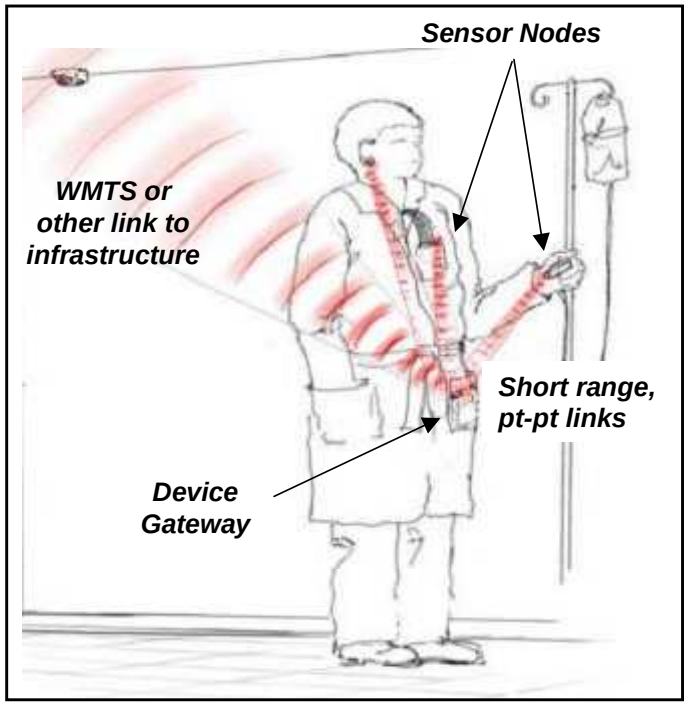
| | |
|---|---|
| Hospital Acuity is Rising | – As the population ages, the average acuity of hospitalized patients will increase rapidly. [1]<br>– In one survey, hospital acuity grew 21% over 5 years. [2] |
| Skilled Labor is Becoming Scarce | – The US is expected to have a shortage of 1 million registered nurses in 2020. [3]<br>– By 2020, the number of doctors specializing in treating critically ill patients in the US likely will not meet the demands of an aging population. [4] |
| Reporting Requirements are Significant | – Currently, hospitals must manage more than 300 external reporting requirements.<br>– In a typical hospital, 40% of patient care time for each active bed is spent manually recording patient information.[5] |
| Next Generation Patient Monitoring Systems Could Play a Role | – 10% of all US hospital beds are located in ICUs.<br>– Adults in the US receive only about 55% of recommended care for a variety of common conditions. [6]<br>– US demand for patient monitoring systems will grow 5.4% annually through 2010, bolstered by technology advances. [7] |

[1] “The Critical Care Workforce: A Study of the Supply and Demand for Critical Care Physicians.” Requested by: Senate Report 108-81
[2] Unruh L. Licensed nurse staffing and adverse outcomes in hospitals. Med Care (AHRQ and NSF study). 2003.
[3] U.S. Department of Health and Human Services.
[4] “The Critical Care Workforce: “A Study of the Supply and Demand for Critical Care Physicians,” Health Resources and Services Administration. 22 May 2006
[5] “ICU Data Center, Inc.”.” University of Florida Office of Technology Licensing October 2006.
[6] "Agency for Healthcare Research and Quality: Frequently Asked Questions." AHRQ. United States Department of Health and Human Services.
[7] “Patient Monitoring Systems to 2010.” The Freedonia Group. 1 May 2006.

# Body Sensor Network (BSN) for Medical Monitoring

## A wireless network of sensors around a patient providing multiple clinical benefits

- Patient mobility, comfort, infection control
- Monitoring flexibility and scalability
- Extension of monitoring into care areas that are currently unmonitored
- Reduced clinical errors
- Reduced overall monitoring costs



# Primary use case for BSN is in clinical environments with other settings to follow

## Hospital

- ER, OR, ICU, Medical/Surgery
- Ambulatory, maternity
- Radiology, transport

## Expanding Beyond Hospital

- Ambulance
- Physician office
- Home, Assisted Living
- School and Office
- First responders
- Military







# Medical BSN Sensor Types

## Body worn sensors

- Individually ~ 1-2+ kbps per sensor
- Aggregate ~ 10+ kbps per patient
- Wireless ~ 1 meter to Gateway

## BSN scales with patient need

- Quickly add/remove to patient
- Various sensor types on single patient

## Unprocessed data

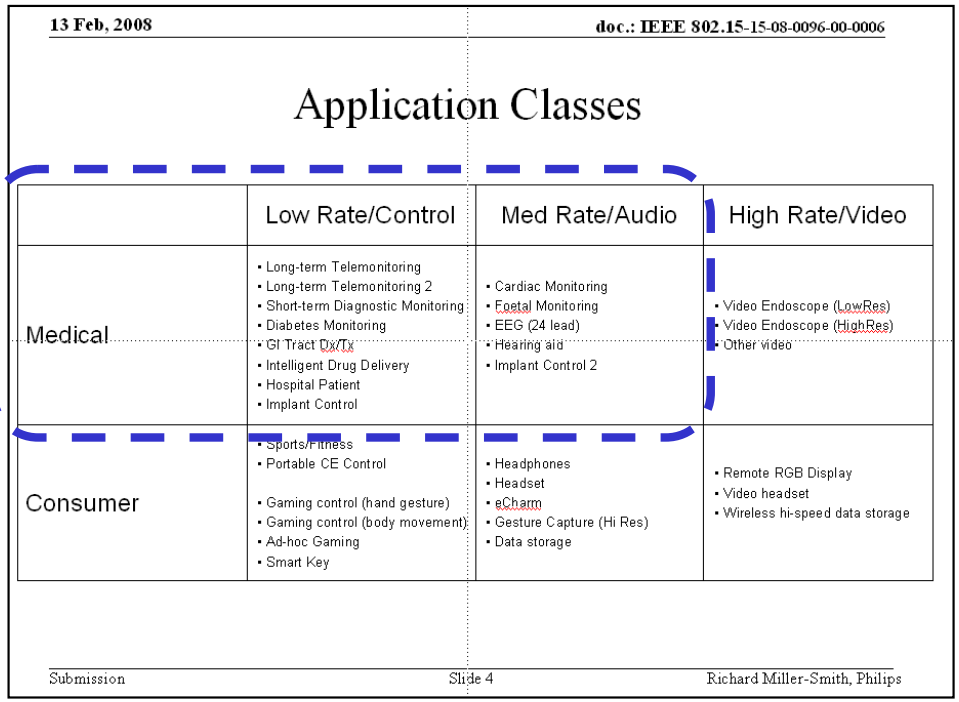
- Alarm algorithms at remote server
- Facilitates disposable devices

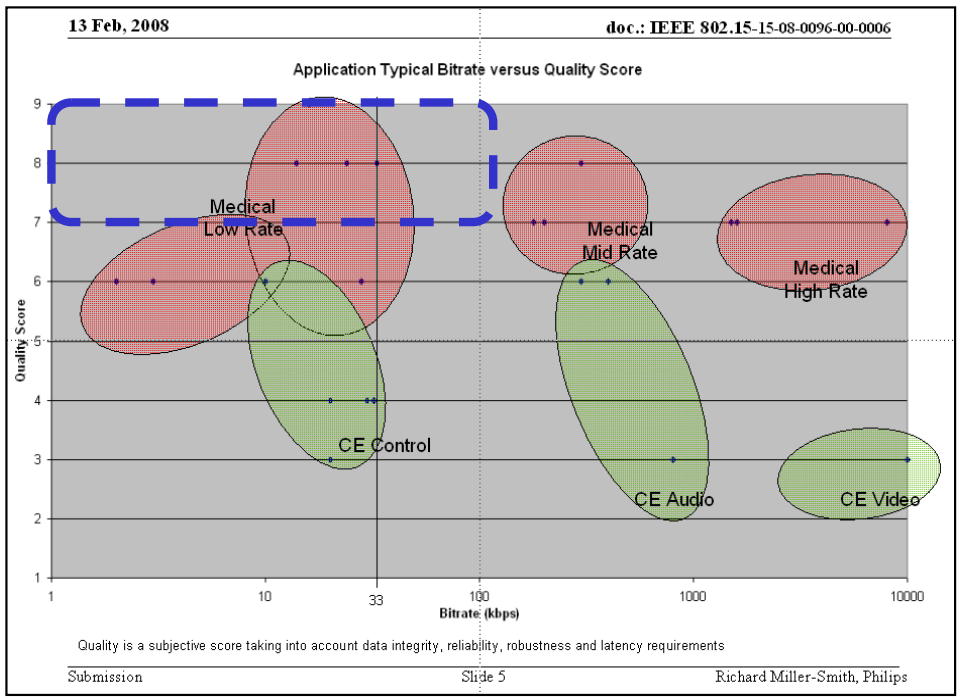
| | | Data rate (per link) | Number of devices (per BSN) |
|---|---|---|---|
| | | low (<200Kbps) | small (<12) |
| Class A | **Medical Applications** | | |
| A1-1 | **Wearable BAN(WMTS)** | | |
| | EEG Electro Encepalography | | |
| | ECG Electro Cardiogram | | |
| | EMG Electromyography (muscular) | | <12 |
| | vital signals monitoring | | <12 |
| | temperature (wearable thermometer) | | <12 |
| | respiratory monitor | | <12 |
| | | | |
| | wearable heart rate monitor | | <12 |
| | SpO2 wearable pulse oximeter | | <12 |
| | wearable blood pressure monitor | | <12 |
| | oxygen | | <12 |
| | pH value | | <12 |
| | wearable glucose sensor | | <12 |
| | | | |
| | **disability assistance** | | |
| | muscle tension sensing and stimulation | | <12 |
| | wearable weighing scale | | <12 |
| | fall detection | | <12 |
| | | | |
| | **human performance management** | | |
| | aiding professional and amature sport training | | <12 |
| | assessing emergency service personnel performance | | <13 |
| | assessing soldier fatigue and battle readiness | | <14 |
| | | | |
| A2-1 | **In Hospital (in general)** | | |
| | **A1&A2 compliant for Healthcare Provider Facilities(24 Hours Services) in FCC Category** | | |
| A2-2 | **Outside Hospital** | | |
| | **A1(WMTS) compliant for except Healthcare Provider Facilities(24 Hours Services) in FCC Category (Ambulance also not allowed)** | | |

*From BAN Application Matrix, IEEE 802.15-07-0735-08-0ban-ban-application-matrix.*

# Medical BSN Application Classes

## Need high link reliability, low power consumption with low-medium data rate for BSN sensor nodes




*From "Application Class Structure" by Richard Miller-Smith, IEEE 802.15-08-0096-00-0006, 13 Feb 2008.*

# Enabling Clinical Environment BSNs

## *Needs*

- Robust wireless link for bounded data loss and bounded latency
- Capacity for patient and sensor density
- Coexist with other radios
- Battery life for days of continuous operation
- Small form factor for body worn devices

## *How's*

- Diversity, error control
  - Time, frequency, CRC, FEC, ARQ
- Symbol rate >> sensor information rate
  - Low duty cycle TDMA
- Contention protocols
  - Frequency agile hopping, Listen-before-talk
- COTS transceivers
  - Size, cost, basic modulation, simple protocols, low EIRP
- Small, efficient antennas

# Medical BSNs require new, protected spectrum for clinical applications

## Unlicensed Bands

- Lack reliability needed for unprocessed, life-critical monitoring data
- Fully utilized by hospital WLAN for mission-critical applications

## 400 MHz MedRadio

- Duty cycle limits force BSN to 3 MHz center of MedRadio band
- 3 MHz insufficient for BSN patient population within hospital

## WMTS

- Limited and disjointed spectrum bands
- Heavily utilized by hospitals for existing telemetry applications
- “Command and control” channel coordination
- Prohibits use in ambulance, home, office

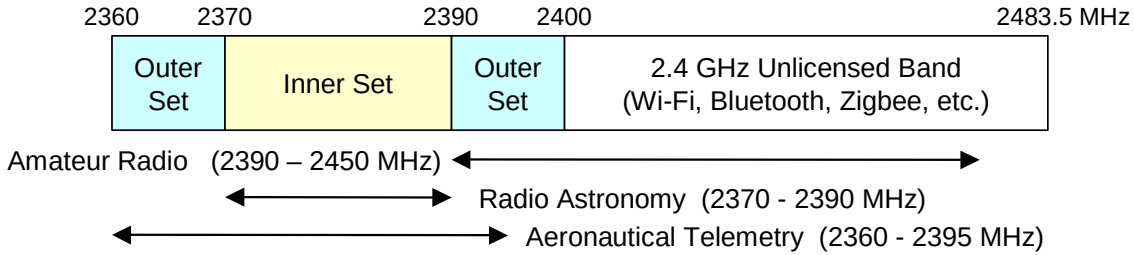
# Proposed Part 95 Rules for Medical Body Area Network Service (MBANS)

## Eligibility & Permissible Communications

- Licenses by rule operations by authorized health care professionals and by any other person, if such use is prescribed by a health care professional. Limited to transmission of data (no voice) used for monitoring, diagnosing or treating patients.

## Frequencies & Authorized Locations

- 2370-2390 MHz limited to health care facilities and other environments where health care professionals monitor, diagnose and treat patients, including in ambulances.
- 2360-2370 MHz and 2390-2400 MHz operations permitted anywhere CB radios may operate.




## Technical Parameters

- All stations must employ unrestricted contention-based protocol.
- Maximum emission bandwidth of 1 MHz.
- Maximum EIRP not to exceed the lesser of 1 mW or 10 log $BW_{20dB\ MHz}$ dBm.
- Same out-of-band (more than 500 kHz outside of band) field strength limits as apply to MICS.

# Why 2360 to 2400 MHz?

- Leverage 2.4 GHz off-the-shelf component integration, capability and volume costs
- Permits small, efficient antennas
- Allows high symbol rate (modulation bandwidth) for low duty cycle and short bursts
- Consultation with NTIA
- Incumbent Aeronautical Telemetry and Amateur operations are good candidates for coexistence

# Why 40 MHz Bandwidth?

- Need to share with primary services

  *"Allocating this 40 MHz of spectrum before sharing is taken into account should provide a reasonable expectation of at least 20 MHz being available for secondary use at health care facilities after avoiding frequencies in use by incumbent services."* *- 27 Dec. 2007,Ex Parte of GE Healthcare to FCC*

  *Many primary incumbent operations have emission bandwidths of several MHz*

- Frequency diversity given ~10 MHz coherence bandwidth and limited selectivity of off-the-shelf transceiver ICs
- Hospital patient density

  *10+ patients, 2+ sensors each*

- Uncoordinated, autonomous operation of multiple MBANS devices (contention protocol inefficiency)

# How will MBANS coexist as a secondary service?

1. Physical separation of low power MBANS devices and incumbent receivers

   Location of airborne vehicle testing “is often restricted to areas over water or uninhabited land in order to preclude danger to life or property in case of catastrophic failure of the vehicle being tested…” Recommendation ITU-R M.1459, 2000, Section 2.2.2

2. Adoption of contention-based protocols

   Frequency agility and hopping, listen-before-talk are effective and proven mechanisms

   - Avoids transmitting on the same frequency as nearby, high power incumbents
   - Permits spectrum sharing with other MBANS devices

# Conclusion

- Medical BSNs afford numerous benefits for clinical environment
- Clinical environment requires balance of robust and efficient wireless techniques
  - Convey unprocessed data continuously for days
  - Bounded data loss and latency
  - Scalable capacity for sensors and patients
  - Coexist among other BSNs and radio sources
- Proposals submitted to FCC requesting new, Medical Body Area Network Service
  - Response to FCC NOI, Investigation of the Spectrum Requirements for Advanced Medical Technologies, ET Docket No. 06-135
  - *Encourage 802.15.6 and others to review and support this proposal*